THE IMPORTANCE OF MINERALS IN THE SWINE RATION

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INTRODUCTION

With the hog growers more and more attempting to meet the demand for smaller cuts of meat and at the same time produce hogs more economically, the value of proper feeding of hogs is becoming of greater importance.

A review of literature reveals a general agreement among research workers that swine, of all farm animals are the most likely to suffer from inadequate rations. This is due to two principal causes. In the first place they are fed largely on grain and can consume relatively little roughage. In the second place they grow more rapidly than other farm animals in relation to their weight at birth with the result that their requirement for essential dietary constituents are more exacting.

The cost of making pork may be cut by feeding for low-cost gains, by finishing hogs for the most favorable market by reducing the overhead expense (housing, sanitation, labor, and feed for sows, etc.) and by raising the largest possible number of finished hogs per sow per year.

Two important discoveries have shortened time required to mature hogs and at the same time have reduced the cost of gains. They are protein and mineral supplements to a cereal ration.

In this particular discussion we are concerned only with the relative importance of minerals in the swine ration.

Feeds which are secured from vegetable sources are much more likely to be lacking in minerals than those of animal origin, such as meat meal tankage, fish meal, skim-milk and buttermilk.

When pigs are given plenty of pasture especially alfalfa or red clover the need for commercial mineral supplements are lessened as such pasture crops contain considerable available mineral. Even with such

a good ration as this, however, a mineral supplement is of some value. Such a ration for instance, may be deficient in the mineral elements carried in common salt and also in iodine or iron.

The Thirteenth Annual Report of the National Livestock and Meat Board has given special attention to pork. R. C. Pollock, general manager, reports that every method of contact in familiarizing the general public with the necessary good qualities of meat is being used. Many people do not stop to think of the special nutritive values which are contained in meats. Meat leads all other foods in proteins of the highest quality. The lean portions of meat, especially beef, are rich in iron which is necessary for protection against nutritional anemia. It helps build red blood cells. The phosphorus of meat helps build strong bone and teeth. Therefore, we might assume that sufficient minerals in the swine ration improves the quality of the meat from the nutritional standpoint.

It was with the view of ascertaining the value of various minerals when used as supplements to the feeds commonly used for hogs in Oklahoma that the study reported in this paper was undertaken.

REVIEW OF LITERATURE

Minerals for Pregnant Sows

Evans (1929), in his study of the protein and mineral metabolism in pregnant sows on a normal or high calcium diet compared with a calcium deficient diet found that the physiological effects of calcium deficiency on pregnant sows demonstrate that a deficiency of lime in the food has no detrimental effect on the live weight of the young piglings at birth thus showing that up to parturition it is the mother organism that suffers and not the offspring.

It is shown that storage of protein during pregnancy is greatly in excess of the foetal requirement, so that the mother organism, during gestation, adds a reserve supply of protein in preparation for parturition and lactation.

From chemical analysis of young piglings it is computed that the calcium-deficient sows had to sacrifice at least 100 gm. CaO. from their own organism for the calcification of the foetus only.

Evans further states that the phosphate retention of the lime-deficient animals is not only postive in all cases, but in three periods is higher than any recorded for the normal sows. The generalization often made that "storage of phosphate is not possible unless lime is being stored as well," is not suppared by this work.

An examination of the blood of both groups of sows demonstrated a deficit of approximately 1,800,000 in the red-cell count of the deficient pigs as compared with the normal sows, indicating a definite though not serious anemia. Slight lymphocytosis was also observed in the calcium deficient animals.

The addition of $CaCo_3$ to the ration resulted in an increased reten-

tion of nitrogen, lime phosphate and potash, but in a decreased retention of soda.

Evans (1932) states that the mineral requirements of pregnant sows have not received nearly so much attention, probably because the skeletal needs of the mature animal are relatively small. Yet it needs to be emphasized that the mineral demands of a sow producing two litters each of eight to ten pigs, annually, with two lactation periods, each of seven to eight weeks' duration, are considerable.

The effects of mineral deficiency on brood sows are most evident about the time of farrowing. Evans finds in an experiment recently carried out at the Animal Nutrition Institute that, if the food was deficient in lime over a period, farrowing became very protracted, with the result that the sows were unable to stand for two or three days afterwards. This led to the loss of whole litters, while the sows became very thin and unthrifty, with consequent delay in the subsequent onset of oestrus (heat) and mating.

Of equal economic significance was the extremely small milk-yield of the lime deficient group, the size of the udders, after farrowing, being markedly smaller than those of another group which had received a similar ration, supplemented by about an ounce of ground limestone.

Evans also found that the heavy mortality among the progeny was probably due to the lack of milk in the mineral deficient sows, whose surviving piglings made very unthrifty live-weight gains, while among these survivors there was a high percentage of deaths at weaning time.

It was found that the offspring of the lime-deficient sows were quite normal in weight and appearance at birth, so that it would appear that, up to the time of parturition, it is the sow that suffers from a mineral deficient diet and not her offspring.

A suitable mineral mixture for pregnant sows (not having access to good grazing) should contain chalk and common salt in the proportion of four parts of the first to one part of the second. This should be fed at the rate of 1 oz. per day. During lactation, about 2½ oz. of the mineral mixture would be required per head daily.

In an experiment relative to the calcium requirement of brood sows, Hogan (1932) found that the rations of brood sows should contain not less than 0.4 per cent of calcium.

The diameter of the metacarpel bone was not decreased by rations deficient in calcium, but the wall was thinner, and was porous instead of being dense and hard.

Davidson (1930), in a study of reproductive disturbances caused by feeding protein-deficient and calcium-deficient rations to breeding pigs, found that the absence of a mineral mixture representing the mineral elements of blood meal produced a very considerable delay in the return of oestrus after weaning. Potassium and iron were the only elements in this mixture not already in good supply in the ration.

A ration deficient in calcium does not produce an immediate effect upon breeding sows, but the effects of the deficiency require one or two generations to become pronounced owing to the capacity of the sow to store lime in the body.

Davidson finds definite evidence that a calcium-deficient diet leads to a very considerable increase in the number of pigs born dead.

A calcium-deficient ration leads to a very serious reduction and eventual failure of the sow's milk supply. This, combined with a large number of pigs born dead and with fatal accidents which are liable to occur, will eventually lead to the extermination of a group of pigs solely confined to this diet.

According to Evvard (1925) the work of Orr and Crichton, of the Rowett Research Institute, of Scotland, has shown that the use of iron under some circumstances is apparently of considerable value. In this regard, Orr may be quoted on his work in feeding brood sows on corn, fish-meal and distillery residues:

> "This ration supplied sufficient lime and phosphorus, and probably also all the other minerals needed except iron. The litters were born apparently healthy, but after the third or fourth week malnutrition was evident. The animals were breathless on exertion, and there were a number of sudden deaths. Post-mortem examination disclosed that the heart was enormously enlarged. The blood was thin and watery, and the harmoglobin--the iron containing part of the blood--was in some cases only 15% of the normal. Other sows were fed the same ration with the addition of iron oxide. The litters from these were perfectly healthy."

A discussion on minerals relative to disease prevention as well as more rapid growth, in Wallaces' Farmer, (1927), relates that brood sows fed an adequate ration, including minerals, during their lifetime will produce litters that are more uniform and vigorous than those receiving no mineral in addition to their ration. It is doubtful if the use of minerals increase the size of litters farrowed, as is sometimes claimed. However, there is no question but the use of minerals is one of several factors that are making possible the saving and raising of larger average litters.

It is further stated that well balanced rations fed continuously greatly reduce trouble at farrowing time and no ration is well balanced without a sufficient supply of the required mineral elements. Under present methods of growing and feeding hogs, most of the feed used is grain, which is low in minerals. A mineral mixture containing calcium, sodium and phosphorus in considerable quantities and some others in small amounts should be supplied to meet the shortage.

Bohstadt, at the Ohio experiment station, has definitely proved that paralysis in the hind quarters of hogs is practically always caused by the feeding of a ration deficient in minerals. With brood sows the body supplies the necessary mineral for the milk from her bones if sufficient amounts are not provided in the ration. Hence if minerals are not provided in the ration paralysis of the hind quarters is common.

Bohstadt also finds that flu, or contagious pheumonia in hogs, is one of the most costly afflictions that come to corn belt farmers. A bulky laxative ration containing sufficient protein and mineral will make the swine herd more resistent to flu.

Minerals for Growing Pigs

A. Iron as a factor in the growth of young pigs. Maynard (1936) in observing the mineral needs of pigs finds that suckling pigs may require additional iron to prevent anemia. Owing to the labored breathing which is always characteristic of severe cases, anemia was known as thumps long before it was discovered to be due to a lack of sufficient iron for blood formation. The trouble is most frequent in litters farrowed in late fall or early spring and kept inside without access to soil or pasture.

Anemia may be prevented, or cured in its early stages, by administering an iron solution to the sucklings either by drenching, or by swabbing the solution on the udder of the sow. Prepare the solution by dissolving one pound of ferrous sulfate or copperas in one quart of hot water. Feeding iron to the mother does not prevent anemia in her young, nor is there ever any need for additional iron in the ration of swine except in the special case of the suckling pigs.

B. The use of calcium, phosphorus and other mineral supplements in the pig ration. According to the Journal Department of Agriculture, South Australia (1934), the mineral requirements of pigs have received considerable attention from research workers in many countries, and a vast amount of information has been obtained on the subject.

It is further stated that from the practical feeders' point of view it is difficult to know when and in what respects the ration he is feeding to his pigs is likely to be deficient in minerals, and what and how much of mineral supplement he should feed.

The only mineral constituents that are ever likely to be lacking to any serious extent in rations fed ordinarily to pigs from weaning to marketing condition are calcium (lime), phosphates, and common salt (naCl).

In a study of minerals for pigs, Davidson (1925) ran an experiment on the value of minerals in fish meal for fattening pigs. A scheme of rations was drawn up in which one lot of pigs got a basal mixture of cereal grains plus 10 percent of fish meal; on which ration it was known that pigs would grow and fatten well. In another lot the same basal mixture of cereals was used without fish meal. The difference between these two pens would show the result due to all the variable constituents combined in fish meal. Finally to determine how much of the value of fish meal was due to the minerals which it supplied, a third ration was designed to include the same basal ration as before with the addition of a mixture of inorganic salts containing mineral elements believed to be deficient in the cereal ration. The pigs employed in the experiment were all pedigreed large whites bred on the Cambridge University farm. All pens were given as much feed as they would clean up.

In relation to the live weight and feed consumption, for the first two weeks, none of the pigs in lots 1, 2, and 3 gained much weight and they were all irregular in their feeding. At the end of that period they appeared to have settled down to their new conditions. Lot 2, on cereals plus mineral mixture, and lot 3, on cereals plus fish meal, remained healthy to the end of the experiment with the exception of one pig in lot 2 which had to be removed on account of illness at the end of the seventh week. Lot 1 on the other hand, which was receiving the basal ration of cereals only, made much slower growth, and the pigs in it developed many of the symptoms associated with a deficient diet. Several of them became very "crampy" and weak and had to be removed during the course of the experiment.

According to Davidson the experiment confirms the results of

previous work carried out by Evvard and others in America and by Orr and Chrichton at the Rowett Institute, Abeerdeen, showing that cereals alone do not supply all the food requirements of the pig.

It also indicates that a large part of the value of fish meal for growth lies in the minerals it supplies. After the pigs were approximately 100 pounds live weight the rate of growth was as great with a mineral supplement only as it was with the addition of fish meal.

Barnett (1917) shows the effect of protein and mineral on the development of swine from an experiment which ran from August 2 to October 25, 1917, in which five lots of pigs containing four pigs to the lot were fed on various rations some containing mineral and others low in minerals.

The following table is a part of this experiment, including lot 1, which was fed on a straight corn ration; lot 2, fed on a ration containing 75% corn and 25% shorts; lot 4, containing 90% corn and 10% tankage; and lot 5, containing 90% corn and 10% ground bone.

In this experiment the pigs were fed the above named rations on alfalfa pasture.

Table I

Growing pigs on corn and supplementary foods on alfalfa pasture.

Ration	Lot 1 Corn	Lot 2 Corn 75% Shorts 25%	Lot 4 Corn 90% Tankage 10%	Lot 5 Corn 90% Ground Bone 10%
Number in Lot	4	4	4	4
Weeks on Expt.	12	12	12	12
Ave. Final Wt. Lbs.	144	142.5	148.5	144.5
Ave. Initial Wt. Lbs.	61.5	61.2	63.2	63.
Ave. Daily Gain Lbs.	.98	.97	1.01	.97
Daily Grain Consumed per pig lbs.	3.4	3.3	3.27	3.1
Grain for 100 lbs. gain- lbs.	343	336	322	336

It will be observed from a study of this table that the feed consumed daily was decreased where 10% of bone meal was added to a straight corn ration. It will also be observed that even on alfalfa pasture the addition of a protein supplement increased slightly the daily consumption of feed.

While the results of this experiment were very much the same in all classes, there appears to be no advantage, but a slight disadvantage in the feeding of bone meal where hogs are fed on alfalfa pasture. It should be observed here, however, that 10 percent bone meal was used, which is decidely more than could possibly be used by the hog.

According to Crowther and Wright (1932) with regard to the pig, observations at the Harper Adams Experiment station and elsewhere has led them to the conclusion that in ordinary pig-feeding practice it would rarely be necessary to use anything more than lime, phosphate and salt in the way of mineral supplements, and a mixture of six parts of ground limestone, five parts of sterilized bone flour and one part of common salt was found to give just as good results as the more complicated and more expensive mixtures commonly offered for sale.

Sinclair and McElroy (1935) found in their work concerning the addition of protein and calcium to a ration of small grains for growing pigs that the calcium of ground limestone can be assimilated by pigs. The addition of ground limestone to the basal ration led to the development of apparently normal bone and increases both the rate of growth and economy of feed utilization. The beneficial effects of adding protein to the basal ration without supplying additional calcium were interferred with by the development of a condition of "stiffness" or crippling in the pigs.

The addition of ground limestone to such rations prevented the development of "stiffness" and promoted growth and more economical feed utilization.

It is further stated that feeding a low calcium diet led to a diminution in the amount of calcium in the blood serum. No consistent changes occurred in the level of inorganic phosphorus. A low-level of calcium in the blood serum was found to be associated with the development of "stiffness" or "crippling".

Feeding ground limestone raised the level of calcium in the blood serum.

Indications were obtained that pigs exhibiting clinical symptoms of abnormal bone development due to a deficiency of calcium have a greater amount of phosphatase present in their blood than have normal pigs.

Cod liver oil added in the basal ration promoted growth and the assimilation of the calcium present in the grains.

No obvious evidence of phosphorus deficiency appeared when a ration containing approximately .35% of phosphorus was used.

Working with phosphorus requirements in the ration of growing pigs, Aubel, Hughes, and Lienhardt (1936) found under the conditions of the three experiments carried on at Manhattan, Kansas, involving three lots each that the requirements of phosphorus in the ration of growing pigs were between 0.27 percent and 0.3 percent.

This represents a daily intake of about 6.5 grams of phosphorus per 100 pounds live weight, when a pig weighs about 50 pounds; and about 4 grams per 100 pounds live weight when a pig weighs about 200 pounds.

Rewiewing the work of other investigators, McClure and Mitchell (1931) found the deleterious effects from the use of raw rock phosphate as a mineral supplement have been attributed generally to its fluorine content.

It was found that mineral supplements containing 2 per cent or more of fluorine appeared to exert a detrimental effect upon the food consumption and growth of pigs, and that fluorine at levels of 3 per cent or more appeared to cause distinct toxic effects.

All mineral supplements were in amounts furnishing 5 gm. of calcium daily.

There were indications that rock phosphate exerted a more detrimental effect than synthetic mixtures of tricalcium phosphate and calcium fluoride containing like percentage of fluorine.

However, the results of feeding fluorides to pigs, even at the highest levels, that is, about 0.017 to 0.026 % of fluorine (0.0035 to 0.0055 gm. per kilogram of body weight) can not be regarded as having demonstrated an effect of fluorine on calcium utilization in intermittent periods of feeding, although there were indications, if nothing more, that these high levels of fluorine depressed calcium metabolism.

Bethke and others (1933) found the calcium phosphorus ratio of ration to be a factor when working with the effect of the calcium-phosphorus relationship of the ration on growth and bone formation in the pig.

Bethke and co-workers found that best results were obtained with a calcium-phosphorus ratio between 1.0 and 2.0.

When the proportion of calcium to phosphorus was greater than

3.0, the pigs became more rachitic and the requirements for vitamin D were increased.

The concentration of calcium and phosphorus in the ration also exerted an effect on growth and bone formation.

Phosphorus, as well as calcium, may be a limiting factor in growth and calcification.

Evidence was obtained indicating that the Phosphorus content of the ration should not be less than approximately 0.60 per cent for good growth and bone formation in the absence of added vitamin D.

The requirement of the pig for vitamin D can be minimized by properly adjusting the calcium and phosphorus content of the ration.

In metabolish experiments upon five pigs, carried on by McClure and Mitchell (1930), in which potassium iodide was adminstered for 14 days in doses of 0.248 gm., and in which 14 day control periods preceded and followed this regime, there was no evidence that the utilization of either nitrogen, calcium, or phosphorus was favorably affected.

There was some indication that the retention of calcium was adversely affected.

No effect of the iodide adminstration on the rate of growth of the pigs was evident.

The experiment run on the relative nutritive efficiency of certain calcium compounds with growing swine by Fraser (1931) shows that all the calcium compounds fed, including ground high calcium limestone, calcium sulphate, bone derived, and bone meal, seemed to promote good growth in fall pigs.

Calcium sulphate, bone derived, was equivalent in feeding value to ground limestone as a source of calcium in the growth of pigs.

During the 90 day period when the pigs were on low calcium levels, a 50-50 mixture of ground limestone and calcium sulphate, bone derived promoted a larger average daily gain and greater feed economy than when either compound was fed alone.

The pigs receiving the limestone-calcium sulphate mineral supplement ate more feed per day but made as efficient use of the feed, producing 100 pounds of gain with about the equivalent amount of feed.

Considering the greater final weight per pig in this group, the feed economy may be considered greater.

Special bone meal proves to be an excellent supplement for swine rations; because of its phosphorus content, it has an obvious advantage over certain other non-phosphate calcium carriers under many conditions of practical feeding.

From an experiment carried on by Hall and De Wal (1926) with maize-meal, green lucerne and bone-meal as a mineral supplement, it was found that the ration of maize-meal and green lucerne as fed supplied almost sufficient phosphoric oxide and lime for the requirements of the pigs used in the experiment. A better gain, and the 24s. 2d. profit from the bone-meal make its use advisable, even with this ration.

An experiment pertaining to the comparitive efficacy of "Dicapho," bone meal, and limestone when fed as mineral supplements to rations for pigs, by Thomas, Culbertson, Ramsbottom and Hammond, (1933) has been carried out and the results based upon 30 metabolism pig-periods of 10 to 14 days duration.

They show that for all, except one pig, when equivalent quantities of calcium, steamed bone meal or Dicapho were fed either at low or

or high levels of intake as supplements to a calcium-deficient basal ration, the retention of calcium and phosphorus was essentially the same.

In the case of the exception limestone made up 1.7 per cent of the ration.

Increasing the amount of phosphorus in this ration, equal to that which would have been ingested in an equivalent amount of bone meal, by the addition of a neutral mixture of mono- and disodium phosphate markedly improved the pigs' retention of both calcium and phosphorus.

The results obtained from several metabolism and feed lot trials conducted simultaneously show that ground limestone, steamed bone meal, and Decapho are utilized by pigs with equal efficiency.

The data collected did not consistently favor any one of the supplements and the variations obtained may be expected from differences in the individuality of the pigs.

Working with potassium iodide as a mineral supplement, Carroll and others (1930) found that a critical analysis of published experiments on the effect of supplemental iodides on growth of animals not obviously suffering from hypothroidism, shows that the majority indicate no beneficial effect and that those experiments which have been interpreted in a postive way are either statistically inadequate or have been demonstrably misinterpreted.

In a paired-feeding experiment involving 13 pairs of poland-china pigs, weighing initially from 57 to 76 pounds and finally about 175 pounds, no evidence was obtained that the administered potassium iodide, equivalent to 1 grain of iodine daily, in any way affected the rate of growth.

The basal ration used contained ground yellow corn, tankage, linseed meal, alfalfa meal, and sodium chloride.

A study of the influence of the addition of calcium carbonate to a ration low in lime on the appetite and digestibility of the food in swine, by Evans (1929) shows that animals on a calcium deficient diet suffered periodically from loss of appetite though the ration was in every other respect satisfactory.

The results of twenty-two digestion trials show no enhanced effect on the digestibility of the organic constituents of the food on adding calcium carbonate to a lime-deficient ration.

Carroll and Others (1930) found that the administration of ferric citrate at the rate of 3 gm. daily to young growing pigs on a ration of yellow corn, soybean oil meal, linseed meal, alfalfa meal, calcium carbonate, and sodium chloride had no effect upon the rate or economy of gains in 12 to 18 weeks of feeding. The paired-feeding method was used in this trial involving ten pairs of pigs.

Minerals for Fattening Hogs

A. The value of minerals in dry lot feeding. In a comparison of minerals for swine, Robinson (1925) finds that they are essential in hog feeding. They are needed in the formation of bone, as a part of the blood, and in the vital processes of the cells. The common feeding stuffs carry varying amounts of the required mineral elements, but, as a general rule, the roughages, particularly the legumes, are much richer in ash or minerals than are the grains and their by-products, practically all of which have a rather low ash content. Rations containing an appreciable amount of forage or roughage are not likely to be greatly deficient in minerals. Since hogs are fed largely on concentrated feeds and often are pushed for an early market under more or less artificial conditions they suffer from insufficient minerals much more frequently than classes of animals which utilize considerable roughage.

The elements most likely to be deficient in rations for swine are sodium, chlorine, calcium, and phosphorus. Very limited amounts of other minerals are needed with some rations and under certain conditions.

Robinson further states, in a comparison of minerals for feeding with corn and soybean oil meal, it was found that the pigs receiving salt, limestone, and acid phosphate gained a little more rapidly than those getting only salt and limestone. There was practically no difference in the gains produced from a given amount of feed from the two lots fed. The mineral mixture of salt, limestone, and bone-meal proved superior to salt and limestone and to salt, limestone, and acid phosphate, just as it did when fed with corn and soybean oil meal. No indications of stiffness or crampiness were observed among the pigs receiving salt, limestone, and bone-meal.

Hoards' Dairymen, (1926) relates the work of the Iowa Experiment station in regard to several feeding trials comparing rations with and without salt. In this particular experiment, pigs weighing 37 pounds each were fed for 160 days--one group receiving shelled corn in a self-feeder and a 39 percent protein supplemental mixture in another self-feeder. Lots 2, 3, 4, 5, and 6 received the same kind of feeds in the same way but in addition had varying amounts of salt. Lot 2 had salt at the rate of one pound mixed with each 100 pounds of the supplemental feed mixture; lot 3 had 2 pounds of salt thus mixed. Lot 4 had 4 pounds; lot 5 had 8 pounds and lot 6 had salt free choice or self-fed separately from the supplemental feed mixture.

The supplemental feed mixture fed each of the six lots was composed of 50 parts of 60 percent tankage, 25 parts of corn oil cake meal, 25 parts of ground alfalfa mixed together and self-fed.

All of the salt fed groups out gained the no salt fed lots and took less feed per 100 pounds gain. The results show that a little salt went a long ways. Lot 6 receiving its salt self-fed free choice is easily outstanding in rate of gain and feed saved. Comparing it with group 1 that did not have salt we find that a pound of salt saved 633 pounds of feed. Lot 1 gained 1.12 per pig per day and consumed 494 pounds of feed for each 100 pounds gain. They weighed 238 pounds at the end of the 180 days of feeding. Lot 6 gained 1.51 pounds daily, consuming 399 pounds of feed for 100 pounds gain. They reached 307 pounds weight at the end of 180 days. Here is a difference of .31 pound in daily gain. 95 pounds feed saved per 100 pound gain and 69 pounds more weight in favor of the salt fed lot. The pigs consumed .15 pound salt for each 100 pound gain.

Mineral mixture feeding is found a good insurance in the hog lot,

according to Evvard, (1926). Mr. Evvard was instrumental in conducting some experimental work with fall pigs in which four groups were fed without any minerals whatsoever,not even salt; four similar groups being allowed a simple mineral mixture made up of common salt, limestone, spent boneblack and potassium iodide, and four other groups similar to the eight mentioned being allowed a more complex mixture, made up of some twelve ingredients, not all of which by any means have yet proved to be essential.

The basal ration fed consisted of shelled corn mixed in color, self-fed, plus a supplemental feed mixture carrying approximately 80 percent of protein, likewise self-fed. This supplemental mixture in the first year's experiment consisted (in pounds) of cottonseed meal, 30; corn oil meal, 20; linseed oil meal, 15; red dog flour, 10; ground soybeans, 7; soybean oil meal (fat extracted), 7; peanut meal, 7; and alfalfa meal 4; total 100 pounds.

All of the groups fed in dry lot were carried until they reached the 225-pound average weight. Plenty of good, wholesome well water was supplied, and the pigs had access, in their yards, to considerable natural soil, gravel and sand, such as carried some mineral constituents. Nevertheless, minerals paid big dividends.

The four groups of seven pigs each, twenty-eight pigs in all, which did not receive any minerals whatsoever, took an average of 185 days to reach the 225-pound weight. The use of the simple mineral mixture reduced the days to 111, a saving of 74 days, equivalent to practically two and one-half months per pig. With the third group receiving the more complex mineral mixture, eight ingredients being added to the four basal ones, the days were still further reduced to 103, a saving of eight days as contrasted with the simple mixture of four ingredients.

The feed required for 100 pounds of gain in the check lots, was on the average 740 pounds for 100 pounds gain. The use of the simple mixture, consumed at the rate of four-fifths of a pound per pig per month, resulted in a saving of 243 pounds of organic feed, they taking only 497 pounds of organic feed nutrients for the hundred-weight gain.

When the so-called complex mineral mixture was used, the pigs consumed it at the rate of one and one-seventh pounds per animal per month, and instead of taking, on the average 497 pounds of feed, as when the simple minerals were fed, they took only 455 pounds for a hundred pounds of gain, a saving of some 43 pounds of organic nutriment.

In the third year we fed a basal ration similar to the check and other groups. In the first two years the "no minerals" lot took 218 days to go from 67 to 300 pounds in weight. The first group alongside, fed similarly in all basal experimental particulars, took two months less time to reach the same weight. The difference was due to salt only, this being added in self-feeders. The feed required for the hundred-weight gain was 574 pounds, as contrasted with 467 pounds, a saving of 107 pounds of feed due to the salt, a little over a half a pound of which was consumed for one hundred pounds of gain made. One pound of salt, in addition to speeding up the pigs, saved approximately 195 pounds of organic feed. In some of our experiments they found that the salt saved as much as 500 or more pounds of feed and greatly accelerated the gain. In salt feeding, too much depends upon the character of the basal ration as to whether or not the salt addition will make much difference. When they use considerable blood meal in the ration, the use of extra salt is not attended with such marked results as where the feeds are all of vegetable character as in the feeding experiment described, blood meal is quite rich in salt.

Maynard, (1936), in a mineral discussion for farm animals finds that a ration for swine consisting of corn, or other grain, and a protein supplement of vegetable origin, such as oil meal, containing little calcium, and the troubles resulting from improper bone development are sure to occur when such a ration is fed. On the other hand, the use of an animal protein supplement, such as tankage, fish meal, skim milk, or buttermilk, provides an excellent source of the needed minerals. Good legume pasture will also help to supply the bone forming elements.

According to tests completed at the Purdue experiment station related in Wallaces' Farmer, (1922), corn and soybeans, supplemented with the right kind of a mineral mixture, proved to be a cheaper and more efficient ration for swine than corn and tankage;

> Wallaces' Farmer, (1923) states that "the present situation seems to favor the use of those materials which can be the most easily and cheapily procured by the feeder. In the light of present experimental evidence salt and lime should be considered as two of the essentials of the mixture. The addition of bone-meal, although it adds to the expense, is worth while for purebred pigs which must be carefully grown out. From the work that has been done so far the feeder may feel assured of just as good results with a simple mixture as with some of the more complicated mixtures which have been suggested."

Morrison, (1923), finds from the results of two extensive experiments carried on at the Wisconsin station that there is no advantage in adding a mineral supplement, such as steamed bone-meal or ground limestone, to the efficient, well balanced ration fed to gilts.

Thompson, (1922) in his study of the effect of protein and mineral on the development of swine found that most of the protein supplements were lacking in mineral, especially calcium, the principal ingredient in bone.

B. <u>The effect of pasture on the mineral requirements of fattening hogs</u>. Wallaces' Farmer, (1922) has found that the Illinois experiments indicate that in a well-balanced ration minerals are not quite so impor-

tant in the case of market hogs as many people have thought.

For three years the Illinois experiment station has been experimenting with minerals for hogs, using a total of 240 pigs in these experiments. When the pigs are in the dry lot, minerals seem to be much more worthwhile than when they are running on rape pasture. A mineral mixture of coal, ground limestone, rock phosphate and salt, when fed to pigs in dry lot, getting a ration of corn, tankage and middlings, saved about 35 cents on each 100 pounds of gain. The mineral pigs reached 225 pounds in weight about 10 days sooner and required about twenty-eight pounds less feed to produce a hundred pounds of gain. Charcoal and air-slacked lime added to the mixture made it less rather than more effective. In fact the third bunch of dry lot pigs, which was fed coal ground-limestone, rock phosphate, salt, charcoal and air-slacked lime, required only 11 pounds less of feed to produce one hundred pounds of gain than the pigs getting no mineral mixture whatever. The inadvisability of adding charcoal and air-slacked lime to the mixture was also indicated by another experiment.

At the same time as these dry lot pigs were receiving their mineral mixtures, similar pigs on rape pasture were being tried on the same mixtures. Here the rape pasture and the tankage seemed to furnish all the minerals the pigs needed. While the mineral pigs reached 225 pounds in weight four or five days sooner, they required one more pound of feed to produce 100 pounds of gain and the cost of a hundred pounds of gain was three cents more in the case of the mineral pigs. On the rape pasture the addition of charcoal and air-slacked lime told the same story as in the dry lot. Since there were 20 pigs in each lot, it is rather safe to assume that either the charcoal or the air-slacked lime was of no value to the pigs.

These workers concluded that mineral mixtures should always be fed to breeding stock, and to market hogs in dry lots. But there is a question as to whether or not it pays to feed mineral mixtures to hogs on good rape pasture or alfalfa, which have tankage in their ration. If oil meal is used instead of tankage to supplement corn, it seems the use of a mineral mixture is much more necessary.

From results of experimental work by Evvard, (1925) it appears, that charcoal feeding may be advantageous under some circumstances, apparently more particularly where vegetable feeds are exclusively used.

Tests showed that high calcium limestone was much better than the particular air-slacked lime which was used. Results have indicated also that 20 percent salt with most mineral combinations an even lesser proportion of salt is probably more nearly correct.

During the run of the experiment, the salt and charcoal fed lot reached the 225-pound weight in 94 days, wheras, the lot receiving only salt took 112 days. The biggest advantage seemed to be in the rapidity of gains; the pasture used was rape.

The Effect of Mineral in Bone

Evans (1930), in an experiment on the influence of a low and high calcium diet on the development and chemical composition of the skeleton in swine, found that the skeletons of young pigs on a ration composed mainly of cereal grains but with the addition of cod-liver oil show a very distinct lack of calcification, the percentage of ash being about 12 percent lower than in the bones of normal naimals.

Calcification of the bones proceeds up to maturity. A difference of about 360 gm. tricalcic phosphate was found between the same mature bones of normal and calcium-deficient animals.

The ratio of lime to phosphate is almost the same in the different bones of the same individual as well as in the normal and rachitic bones of swine.

The main characteristic of the bones in low-calcium rickets is a low-ash content, but the composition of the ash is normal.

Rice and Mitchell (1924) studying the quality of bone of swine on grain rations in reviewing the work of the Nebraska and Iowa experiment stations made the following observations. It has been shown that mineral supplements and feeds rich in minerals do not have an appreciable effect, if any at all, on the dimensions or the volume of the bones, but that they may markedly increase the density, the thickness of wall, the hardness, and the breaking strength.

The following figures taken from the Nebraska report show clearly the favorable effect of certain rations on the breaking strength of bones.

Comparative Breaking Strength of Bones of Hogs on Various Rations

Ration	Average Breaking Strength per 100 lbs. Live Weight				
	Femur	Tibia	Humerous	Ulna-Radius	All bones
Corn alone	276	252	434	341	325
Corn 75, Shorts 25	343	309	555	376	396
Corn 25 Skimmilk 75	462	360	685	529	509
Corn 90, Tankage 10	559	409	740	611	580
Corn 90, Ground bone 10	646	465	898	715	681

An increase in strength of more than 100 percent was secured by the feeding of ground bone with corn, and only a slightly smaller increase by the feeding of tankage.

There seems to be no definite upper limit to the storage of minerals in the skeleton and to the increased density and strength associated with it.

In experiments with growing rats, on a study of phospatic limestone as a mineral supplement, Tolle and Maynard (1927) found calcium of phosphatic limestone to be as well utilized for bone formation, as measured by ash content, as was the calcium of bonemeal or of limestone.

Phosphatic limestone proved as satisfactory a source of calcium for growing pigs, as measured by ash content of the bones, rate of growth, and economy of gains, as was a mixture of limestone and bonemeal.

While rats receiving 2 percent or more of phosphatic limestone in their diet showed the teeth changes indicative of excess fluorine, levels up to 5 percent resulted in bone of normal ash content over an experimental period of thirty-five days.

A total of 26 pigs received levels of 1.5 to 3 percent of phosphatic limestone with uniformly satisfactory results over a four-months period.

No teeth changes nor any other significant pathological effects were evident upon autopsy.

Studies with rats with different levels of phosphatic limestone, to observe it's effect on reproduction and lactation, resulted in variable and inconclusive data. However, a group of animals that were fed 3 percent of the product from weaning, continued to reproduce and rear their young for five matings fully as satisfactory as did a group receiving ground limestone.

This good performance resulted in spite of very severe teeth changes that gradually developed from the feeding of the phosphatic limestone and that were due apparently to the presence to have accumulated in the body of the rat.

Bohstedt found "precipitated bone flour," a by-product of gelatin manufacture, when fed to the extent of 2 pounds with every 100 pounds of the basal mixture caused a dense, hard, and strong bone in the pigs.

Limited data showed dicalcium phosphate to be superior to tricalcium phosphate as a mineral supplement.

As a result of several trials, in which ninety-five pigs were used, in a study of the Dietary Relationship and the Pathology of "stiffness" in swine, Maynard, Goldberg, and Miller (1925) reported twenty-three cases of stiffness produced.

The principal and constant lesions were found in the long bones, this finding being based on a comparative study of the bones of eighteen stiff pigs and eleven pigs normal in this respect, including microscopic examinations in fifteen cases.

The constant lesions in the bones were: Imperfect calcification, granulation tissue, degenerated areas of articular cartilage, osteoclasts slong the trabeculae, and hemorrage.

In all the stiff pigs examined, the cortex of the kidneys was pale and the medulla was congested.

In more than 50% of the cases, the kidneys and the mucosa of the bladder showed numerous petechiac. The collecting tubules were markedly dilated.

The results show wide variation in the susceptibility of the pigs to the development of stiffness.

Seldom did any ration produce the trouble in all the pigs receiving it. With similar rations there were always more cases of stiffness in winter than in summer.

Even in the same trial and on the same ration, it was not uncommon for one pig to become stiff within six weeks and another to escape the trouble entirely for a period of three or four months.

Although this variation in the development of stiffness may be partly explained by possible differences in initial nutritional state, it appears that other factors also are concerned.

The favorable effect of sunlight proved for small animals and human beings, may have been a factor in the larger number of cases in the winter. However, these animals were housed as to receive very little direct sunlight at any time.

EXPERIMENTAL

Plan of Experiment

In order to determine the value of minerals in the swine ration, a feeding trial was carried out in which five lots of pigs were used.

Forty head of fall pigs were divided as evenly as possible into five lots of eight pigs each. These pigs were fed in pens which had concrete floors; they had no access to dirt. They were housed in a shed open to the south.

The pigs used in this trial were selected from three different breeds of hogs. Care was taken to get pigs of uniform size, age, quality, and conformation.

The pigs from the various breeds were all purebreds. Six Duroc-jersey, one Poland-china and one Berkshire were put in each of the five lots at the beginning of the experiment.

Although the pigs within a lot were not uniform, the five lots of pigs balanced each other. And due to this fact it seemed logical to believe that a trial of this kind would, along with other information, give some knowledge as to the importance of minerals in a swine fattening ration.

Lot no. I - received equal parts (by weight) of yellow corn and wheat shorts, plus salt.

Lot no. II - received the same ration as lot I with the exception that a mineral mixture was fed.

Lot no. III - received a ration made up of 25 parts yellow corn; 55 parts shorts; and 20 parts molasses, plus a mineral mixture.

Lot no. IV - received a ration made up of 40 parts molasses and 60 parts shorts, plus salt.

Lot no. V - received the same ration as lot IV with the exception

that a mineral mixture was fed.

The mineral mixture was made up of equal parts of salt; bone-meal and ground limestone. Salt and the mineral mixture, when used, were fed free choice.

The feeds used in each of the five lots were mixed and enough water added to make a thick slop, which was hand fed.

Fresh water was kept before the pigs of each pen at all times. The concrete platform upon which the pigs were housed and fed was cleaned three times a week and fresh straw replaced for bedding.

On the sixty-third day each pig from the five lots used in this feeding trial were given a thorough oiling for lice.

The pigs used had previously been allowed to run on alfalfa pasture, and received ground corn, shorts, tankage and mineral matter of their own selection in a compartment self-feeder.

The individual pigs were weighed seven different times during the trial; five of the weighings were at ten day intervals. The amount of feed consumed for the various intervals was calculated. The average weight per pig, average daily gain of pigs, average amount of feed consumed, amount of feed consumed per 100 pounds liveweight, feed required and cost per 100 pound gain at each particular interval was kept.

The feeds used were yellow corn shipped in from Argentine, wheat shorts bought at one of the local feed stores, and blackstrap molasses which was bought at Oklahoma City in 600 pound drums after being shipped through in tank cars.

The minerals used were, bone-meal, salt, and ground limestone. This feeding trial started on January 15, 1937 and closed April 14, 1937.

Results

The average weight per pig taken at various intervals for each of the five lots of hogs is shown in table no. I, page 32.

One barrow in lot no. I died of flu on February 3rd. Since this appeared to be no fault of the ration, and since it was so early in the trial, his feed records were estimated and allowance made for them and he was dropped from the trial.

The pigs of lot I, table I, which were fed equal parts corn and shorts without the presence of mineral had an average weight per pig of 163 pounds at the close of this trial. This was the samllest of the five lots. The largest average weight per pig was found to be lot no. III, which was 202 pounds a difference of 39 pounds per pig.

This lot received 25 parts corn, 50 parts shorts and 20 parts molasses, plus a mineral mixture.

Two pigs in lot I came down with rickets, one on March 23rd and the other on March 26th, and were removed from the pen. Their records were included in the project.

The two pigs which showed unmistakable symptoms of rickets before the end of the trial, became very stiff and had difficulty in getting up or in walking. They were so bad that they could not get up without help. After these pigs were removed from the trial they responded to a codliver oil and mineral treatment. These pigs were given one tablespoon full of codliver oil twice daily in addition to the mineral mixture which was placed before them free choice.

Seven days after these pigs started receiving a codliver oil and mineral treatment, one was slaughtered and some bone samples taken. Rickets had developed to such an extent that the bone samples showed to be of very poor quality.

The remaining pig was allowed to live and a striking observation was made in that it showed a definite sinking over the loin. Previous to the development of rickets this pig had a comparatively high back. The presence of rickets caused the development of a flat low top line.

Table I

Average Weight Per Pig Taken

At Various Intervals

Lot Number	I	II	III	IV	V
Ration:	Corn 50 # Shorts 50 # Salt	Corn 50 # Shorts 50 # Mineral Mixture	Corn 25 # Shorts 55 # Molasses 20 # Mineral	Shorts 60 # Molasses 40 # Salt	Shorts 60 # Molasses 40 # Mineral Mixture
Date of Weights Taken					
January 15	77	77	78	76	76
February 17	106	110	111	99	101
February 27	116	119	122	107	110
March 9	132	140	142	126	130
March 19	141	153	156	140	144
March 29	148	165	170	158	163
April 8	154	176	187	171	178
April 14	163	189	202	189	193

The average daily gain of the pigs taken at various intervals is shown in table no. II, page 34. It is quite evident that the pigs in lot I show to be very inconsistent in average daily gains. The fact that they were affected with rickets which was probably due to the lack of sufficient mineral, was no doubt responsible for this condition.

The pigs in lot IV did not show any pronounced symptoms of rickets.

This indicates that molasses is more effecient than corn in preventing rickets but it is necessary to add mineral to the molasses and shorts ration for the best results.

An analysis of variance of the daily gains discloses that the variance between lots on the average is not great enough to be significant. If lot I is compared with the other lots it is found that a difference of .31 pounds in daily gain is necessary for significance. A difference of this magnitude is found between lots I and III but the difference between lot I and the other lots is barely below the point of significance. No significant differences were found between lots II, III, IV, or V as far as daily gains were concerned.

On April 12, four pigs were slaughtered for the purpose of taking bone samples. One pig was taken from each of lots I, II, IV, and V. This was to make possible a comparison between the mineral and non-mineral lots as to the thickness of bone. There was no significant difference found. However, observation showed the bone from the non-mineral pigs to be of softer texture than that of the mineral pigs. This indicates that minerals in a ration fed to dry lot pigs will eventually improve the hardness of bone.

Table II

Average Daily Gain of Pigs

To Date at Various Intervals of Experiment

Lot Number	I	II	III	IV	V
Ration:	Corn 50# Shorts 50# Salt	Corn 50# Shorts 50# Mineral Mixture	Corn 25# Shorts 55# Molasses 20# Mineral	Shorts 60# Molasses 40# Salt	Shorts 60# Molasses 40# Mineral Mixture
Date of Weights Taken					
January 15, 1937 Average Initial Weight	77.	77.	78.	76.	76.
February 17	.88	1.00	1.00	.70	.76
February 27	.90	.98	1.02	.72	.79
March 9	1.04	1.18	1.21	.94	1.02
March 19	1.02	1.19	1.24	1.02	1.08
March 29	.98	1.22	1.26	1.12	1.19
April 8	.98	1.23	1.31	1.18	1.23
April 14	1.04	1.32	1.39	1.29	1.33

The average amount of feed consumed per pig per day at various intervals during the experiment is shown in table III

Table III

Average Amount of Feed Consumed

Per Pig Per Day at Intervals During Experiment

Lot Number	I	II	III	IV	V
Ration:	Corn 50# Shorts 50# Salt	Corn 50# Shorts 50# Mineral Mixture	Corn 25# Shorts 55# Molasses 20# Mineral	Shorts 60# Molasses 40# Salt	Shorts 60# Molasses 40# Mineral Mixture
Experiment started Jan. 15, 1937					
February 17	5.38	5.69	5.54	4.69	4.69
February 27	5.60	5.50	6.46	6.38	6.38
March 9	6.15	6.50	6.93	6.83	6.83
March 19	5.90	6.94	8.00	7.93	7.93
March 29	6.18	6.28	7.14	7.50	7.50
April 8	6.74	7.14	8.30	10.95	9.18
April 14	6.27	6.50	7.50	7.98	9.03

The smallest average daily consumption of feed was found in lot no. I. This fact, further shows that the lack of minerals was a distinct drawback to this lot since these same pigs also made the least average daily gain.

Lot III was most consistent in average daily consumption of feed. This lot,also, consumed the largest amount of feed and made the greatest average daily gains.

During the first thirty days lots IV and V, on the average, consumed less feed than the other three lots. This may be contributed to the fact

that the pigs receiving molasses scoured badly at first but this did not seem to handicap them after the first few days. During the last 30 days these same lots consumed the largest amount of feed

The amount of feed consumed per hundred pounds of live weight during the experiment is shown in table IV.

Table IV

Amount of Feed Consumed Per Hundred Pounds

of Liveweight During Experiment

Lot Number	I	II	III	IV	V
	Corn 50# Shorts 50# Salt	Corn 50# Shorts 50# Mineral Mixture	Corn 25# Shorts 55# Molasses 20# Mineral	Shorts 60# Molasses 40# Salt	Shorts 60 # Molasses 40# Mineral Mixture
Experiment started Jan. 15, 1937					
February 17	5.5	6.0	5.8	5.3	5.3
February 27	5.0	4.8	5.5	6.2	6.0
March 9	4.9	5.0	5.3	5.8	5.7
March 19	4.3	5.0	5.4	6.0	5.8
March 29	3.9	4.2	4.4	5.1	4.9
April 8	4.1	4.3	4.7	5.8	5.4
April 14	3.5	3.5	3.9	4.7	4.4
Average for the 89 day trial	4.02	4.14	4.39	4.85	4.70

The purpose of this table is to show the relative palatability of the various rations used.

Lots IV and V receiving molasses and shorts eat more feed throughout the experiment with the exception of the first 33 days. There seemed to

be no significant difference between lots I, II, and III.

The feed required and cost for a 100 pounds gain is shown in table V.

Table V

Feed Required and Cost for a Hundred

Pounds of Gain *

Lot Number	I	II	III	IV	V
Experiment started Jan. 15, 1937					
Feed Used					
Corn	276	232	122	---	---
Wheat Shorts	276	231	262	303	295
Total Feed Required for 100# of Gain	552	463	482	505	491
Cost of Feed per Hundred Pounds of Gain	$11.05	$9.28	$8.67	$8.13	$7.91

* Cost of Feeds

Cost of feeds are based on current prices. The prices listed below are the actual costs of the feeds, with the exception of the ground limestone, delivered at the barn.

Feed costs were based on the following prices:

Corn (yellow)	$1.15 per 100 pounds.
Shorts (wheat)	1.95 " " "
Molasses (Blackstrap)	1.10 " " "

Minerals

Bone-meal	2.50 " " "
Salt	.60 " " "
Ground Limestone	

The smallest amount of feed for 100 pounds gain was required in

lot II, which received corn and shorts, plus mineral. The cost was second highest in the trial, however.

The cost in lot III was higher than in either lot IV or V, the two lots which received molasses. This was due to the higher price of corn.

Photograph by author, 1937.

Lot no. I showed unmistakable symptoms of rickets and made the lowest average daily gains of the five lots used in this trial. Note the crooked hind leg of the pig in the foreground. This lot received corn and shorts without the addition of mineral.

Photograph by author, 1937.

Lot no. II receiving corn and shorts plus mineral consumed the smallest amount of feed for 100 pounds of gain. The cost was second highest in the trial, however.

Photograph by author, 1937

Lot no. III receiving corn, shorts and molasses plus mineral was most consistent in average daily consumption of feed. This lot also consumed the largest amount of feed and made the greatest average daily gains.

Photograph by author, 1937.

Lot IV receiving molasses and shorts without the addition of mineral showed no promounced symptoms of rickets.

Photograph by author, 1937.

Lot V receiving shorts and molasses plus mineral made the most economical gains of the five lots used in this trial.

DISCUSSION

The Effect of Rickets on the Weight and Average Daily Gain

The author of this paper is inclined to believe from results found that the stiffness or rickets which developed in the two pigs found in lot I is largely due to the lack of mineral. This fact, no doubt, accounts for the low average weight and daily gains made.

The two rachitic pigs in lot I which showed stiffness and difficulty in moving about indicates variation in the susceptibility of pigs to the development of stiffness when fed a non-mineral ration. This is substantiated in an experiment run by Maynard, Goldberg, and Miller (1925) in a study of the Dietary relationship and Pathology of "stiffness," in which ninety-five pigs were included, in all, and twenty-three cases of stiffness were produced.

Seldom did any ration produce the trouble in all the pigs receiving it according to the above authorities. Even in the same trial and on the same ration, it was not uncommon for one pig to become stiff within six weeks and another to escape the trouble entirely for a period of three or four months.

Although this variation in the development of stiffness may be partly explained by possible differences in initial nutritional state, it appears that other factors also are concerned.

The fact that lot IV showed no pronounced symptoms of "stiffness" or rickets indicates that molasses is more efficient than corn in preventing rickets. However, lot IV made next to the least average daily gains of the five lots used, and even though results show no significant difference in gains made by lot IV and the other lots, it is logical to believe that minerals would help bring the average weight and daily gains

up with the mineral fed lots.

The Effect of Mineral on Amount of Feed Consumed and Palatibility of Ration Used

Lot I receiving a ration of corn and shorts without the addition of the mineral consumed the greatest amount of feed per 100 pounds of gain. These results agree with the work of Evvard, (1926) in which some experimental work with fall pigs was carried on. Four groups of hogs were fed without mineral whatsoever, and four similar groups were allowed a simple mineral mixture made up of common salt, limestone, spent boneblack and potassium iodide.

The four groups of seven pigs each, twenty-eight pigs in all, which did not receive mineral in their ration, took an average of 185 days to reach the 225 pound weight. The use of the simple mineral mixture reduced the days to 111, a saving of 74 days, equivalent to practically two and one-half months per pig.

The feed required for 100 pounds of gain in the check lots, the ones receiving no minerals, was on the average 740 pounds for 100 pounds gain. The use of the simple mixture, consumed at the rate of four-fifths of a pound per pig per month, resulted in a saving of 243 pounds of organic feed, they taking only 497 pounds of organic feed nutrients for the hundred-weight gain. The wide variance found here is no doubt due to the four groups of pigs receiving no mineral whatsoever, not even salt.

This shows that pigs requiring more feed per 100 pounds gain also require a longer period to reach the desired 225 pound weight.

As far as the author's knowledge goes minerals have no effect on palatibility of the rations fed.

However, a significant difference was found in the palatability of

the rations used in this feeding trial. The shorts and molasses ration proved significantly more palatable with lots IV and V than the rations fed to lots I, II, and III, receiving no molasses.

Lots IV and V consumed the molasses readily from the start. However, the author is inclined to believe that a ration containing a high percent of molasses would need plenty of protein, mineral and vitamins since molasses are low in such constituents.

The Effect of Mineral on Feed Required and Cost per 100 Pounds Gain

The slow gains and high prices per pound of gains found in lot I was largely due to the lack of mineral in the ration. Further evidence presented by Sinclair and McElroy, (1935) shows similar results.

The author is convinced that this trial shows the necessity of adding a mineral supplement to rations of corn and shorts. It also indicates that the addition of mineral improves a ration of molasses and shorts.

SUMMARY AND CONCLUSIONS

1. Mineral mixture feeding is economical and a good insurance of health when fed to breeding stock and dry lot fed hogs.

2. According to a review of literature the elements likely to be deficient in rations for swine are sodium, chlorine, calcium, and phosphorus. Very limited amounts of other minerals are needed with some rations and under certain conditions.

3. Brood sows that have been fed an adequate ration, including minerals, during their lifetime will produce litters that are more uniform and vigorous than those receiving no mineral in addition to their ration.

4. Paralysis in the hind quarters of hogs is practically always caused by the feeding of a ration deficient in minerals.

5. The skeletons of young pigs on a ration composed mainly of cereal grains even with the addition of cod-liver oil show a very distinct lack of calcification, the percentage of ash being about 12 percent. lower than in the bones of normal animals.

6. The main characteristic of the bones in low-calcium rickets is a low-ash content, but the composition of the ash is normal.

7. There seems to be no definite upper limit to the storage of minerals in the skeleton and to the increased density and strength associated with it.

8. The feeding of loose alfalfa hay to brood sows and the inclusion of 5 percent. of chopped alfalfa in the grain fed to growing pigs, practices which have recently proved to be useful in making a better ration in several respects, help to supply needed calcium.

9. From chemical analysis of young pigs it is computed that the calcium-deficient sows had to sacrifice at least 100 gm. CaO from their

own organism for the calcification of the foetus only.

10. A calcium-deficient ration leads to a very serious reduction and eventual failure of the sow's milk supply.

11. Feeding ground limestone raised the level of calcium in the blood serum of young pigs.

12. A low level of calcium in the blood serum was found to be associated with the development of "stiffness" or "crippling."

13. Phosphorus, as well as calcium, may be a limiting factor in growth and calcification

14. Calcium sulphate, bone derived, was equivalent in feeding value to ground limestone as a source of calcium in the growth of pigs.

15. Limited data showed dicalcium phosphate to be superior to tricalcium phosphate as mineral supplement.

16. This trial shows the necessity of adding a mineral supplement to rations of corn and shorts. It also indicates that the addition of mineral improves a ration of molasses and shorts.

17. The most rapid and economical gains were made by the pigs which received molasses.

18. The smallest amount of feed for 100 pounds gain was required by the group of pigs, which received corn and shorts, plus mineral. The cost was second highest in the trial, however.

19. The non-mineral pigs receiving molasses and shorts did not show any pronounced symptoms of rickets. This indicates that molasses is more efficient than corn in preventing rickets but it is necessary to add mineral to the molasses and shorts ration for the best results.

20. The development of rickets in the pigs receiving corn and shorts without the addition of mineral was due to the lack of this item in the ration. This also accounted for the low and high priced

gains received by this group.

21. An analysis of variance of the daily gains discloses that the variance between lots on the average is not great enough to be significant.

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